

Chem 20A Final Exam, Winter 2018

Name: _____

ID: _____

Exams

Please note: your grade will be based on the best 5 questions you answer! You can pick just five questions to answer, or if you answer all six we will grade you based on the best 5 out of these six.

Some Physical Constants:

$$h(\text{Planck constant}) = 6.63 \times 10^{-34} \text{ J} \cdot \text{s} = 4.14 \times 10^{-15} \text{ eV} \cdot \text{s}$$

$$c(\text{velocity of light}) = 3 \times 10^8 \text{ m/s}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

$$N_A(\text{Avogadro's constant}) = 6.02 \times 10^{23} \text{ mol}^{-1}$$

$$m_e(\text{mass of electron}) = 9.1 \times 10^{-31} \text{ kg}$$

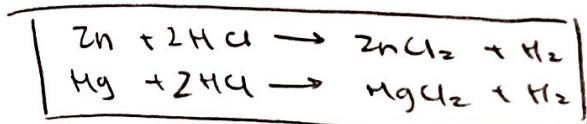
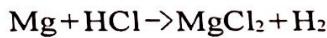
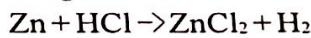
$$1 \text{ Rydberg} = 13.6 \text{ eV} = 2.18 \times 10^{-18} \text{ J}$$

$$a_0(\text{Bohr radius}) = 0.53 \text{ \AA}$$

$$1 \text{ \AA} = 10^{-10} \text{ m}$$

Question	Points	Maximum
1	20	20
2	10	20
3	17	20
4	16	20
5	13	20
6	19	20
Best 5 total		100

a) Balance the equations for the following reactions



10 ✓

b) A 5.0 g mixture of Zn and Mg is dissolved in aqueous HCl to produce 0.2585 g of hydrogen gas H_2 . What is the percent of Zn by mass in the mixture?

$$\text{A g Zn} \times \frac{1\text{mol Zn}}{65.409\text{g Zn}} \times \frac{1\text{mol H}_2}{1\text{mol Zn}} \times \frac{2.016\text{g H}_2}{1\text{mol H}_2} \\ + \left((5 - \text{A}) \text{ g Mg} \times \frac{1\text{mol Mg}}{24.305\text{g Mg}} \times \frac{1\text{mol H}_2}{1\text{mol Mg}} \times \frac{2.016\text{g H}_2}{1\text{mol H}_2} \right) = .2585 \text{ g H}_2$$

$$\frac{2.016}{65.409} \text{ A} + \frac{5(2.016)}{24.305} - \frac{2.016}{24.305} \text{ A} = .2585 \text{ g H}_2$$

$$\text{A} \left(\frac{2.016}{65.409} - \frac{2.016}{24.305} \right) = .2585 - \frac{5(2.016)}{24.305}$$

$$\text{A} = \frac{.2585 - \frac{5(2.016)}{24.305}}{\frac{2.016}{65.409} - \frac{2.016}{24.305}}$$

$$= 2.9972 \text{ g Zn}$$

$$\frac{2.9972 \text{ g Zn}}{5 \text{ g Zn + Mg}} \times 100\% = \boxed{59.99\%}$$

2. a) Using Bohr model, give an estimate of the volume of a hydrogen atom. Bohr radius a_0 . Then estimate its volume by plugging numbers into your formula when electron is moving in its ground state ($n=1$). Write your final answer in terms of angstrom cubed ($1 \text{ \AA} = 10^{-10} \text{ m}$).

$$V = \frac{4}{3} \pi r^3$$

$$r = \frac{n^2}{2} a_0$$

$$V = \frac{4}{3} \pi \left(\frac{n^2}{2} a_0 \right)^3 \quad z=1$$

$$V = \frac{4}{3} \pi a_0^3 \quad n=1$$

$$= \frac{4}{3} \pi (0.529 \text{ \AA})^3$$

$$= 1.62 \text{ \AA}^3$$

10 ✓

b) Now let's assume that electron is 1000 times heavier than what it really is. Would this change the volume of an H atom, and by how much. Be very careful in answering this question!

This would not change the volume of the H atom because the formula for volume $[V = \frac{4}{3} \pi n^6 a_0^3]$ does not show that it is proportional to the mass of an electron in any way.

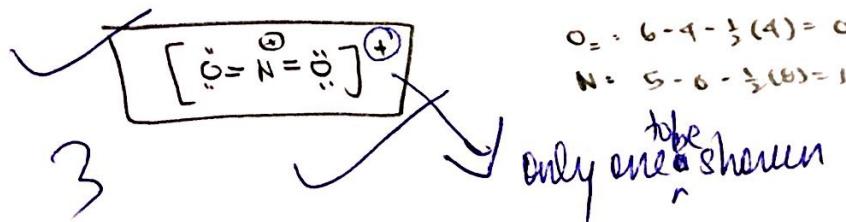
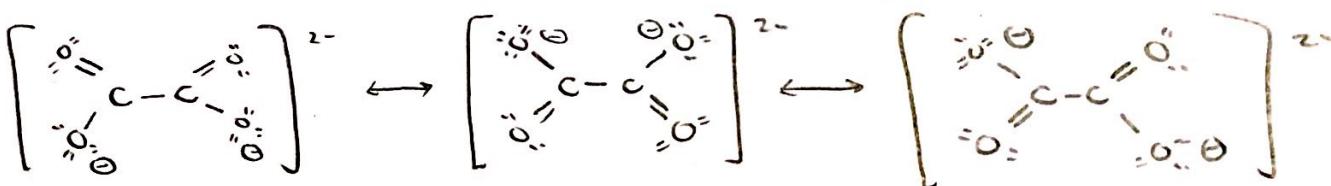
X

ID:

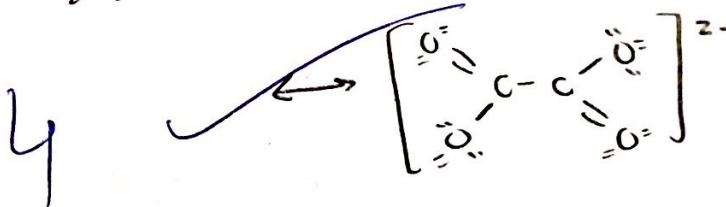
3.

a) Draw the lewis structure of NO_2^+

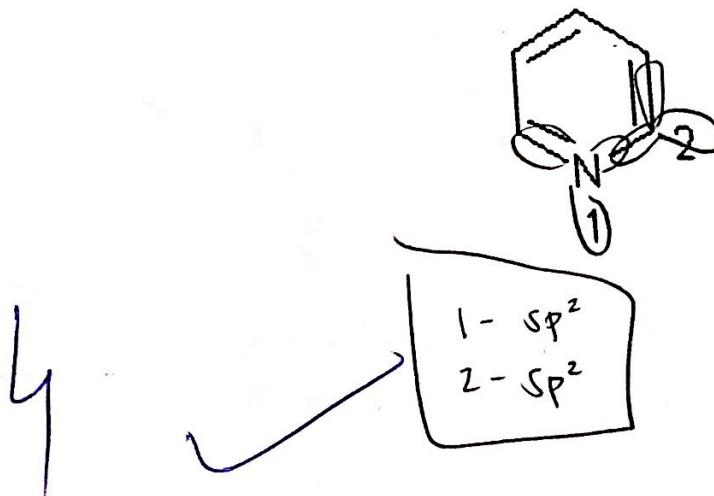
$$5 + 2(6) - 1 = 16 \text{ valence electrons}$$

b) Draw the lewis structure and all resonance structures of $\text{C}_2\text{O}_4^{2-}$ (Hint: the carbons are the central atoms and the oxygens are attached to them) $2(4) + 4(6) + 2 = 34 \text{ valence electrons}$ 

$$0_1 = 6 - 6 - \frac{1}{2}(2) = -1$$



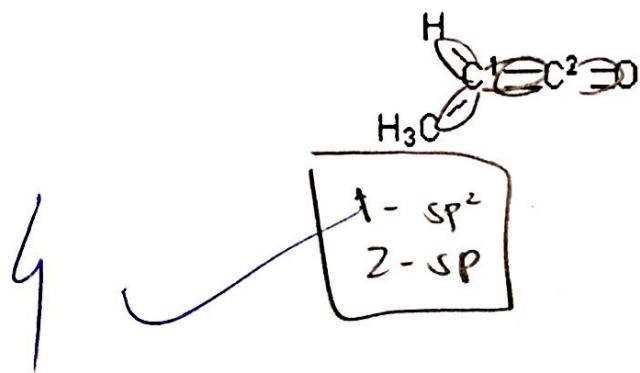
c) What are the hybridizations of atoms 1 and 2 respectively in the following structure?



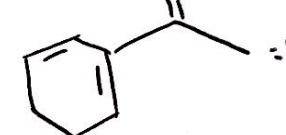
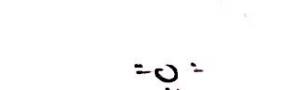
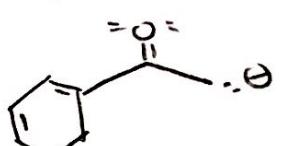
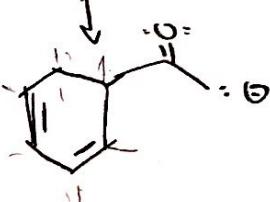
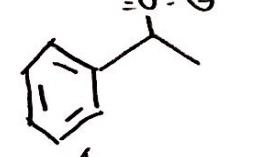
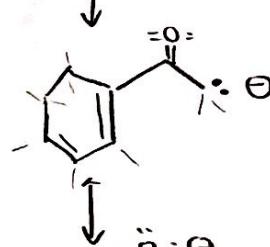
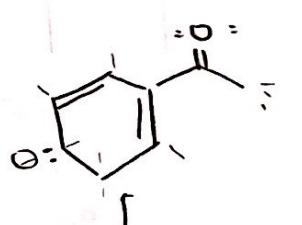
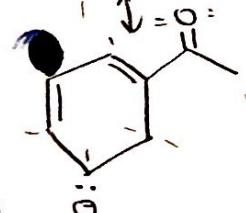
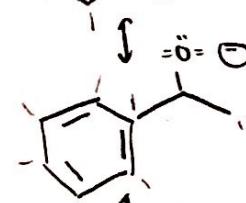
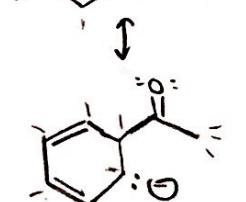
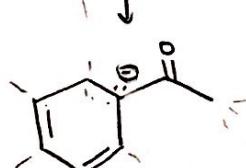
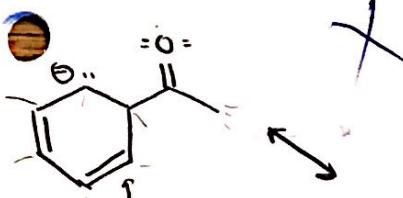
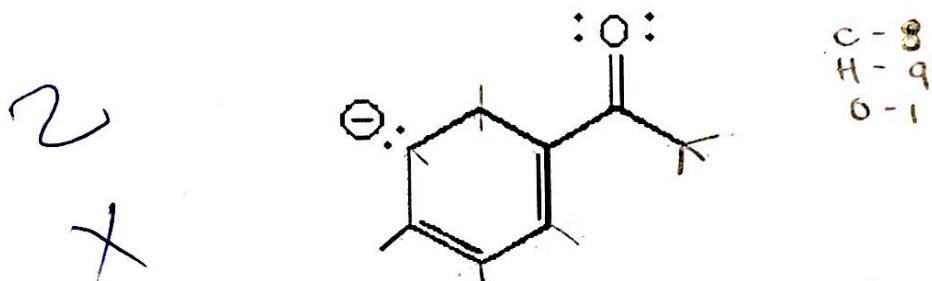
ID:

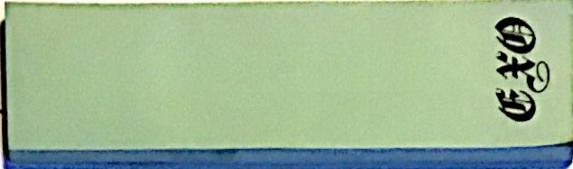
卷之四

d) What are the hybridizations of atoms 1 and 2 respectively in the following structure?



e) Draw all the other resonance structures of the following species.



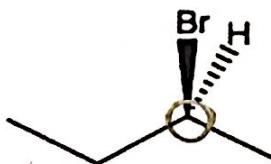
ID: 

4.

Circle all the chiral carbons (if any) in the following molecules. Draw all their stereoisomers if there are any.

a)

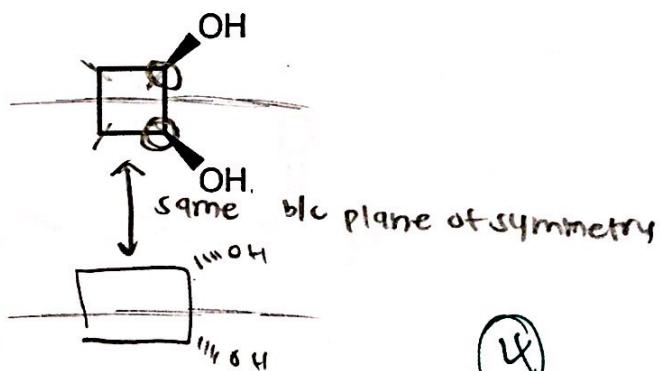
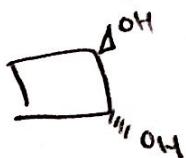
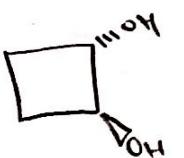
$2^1 \rightarrow 2$ stereoisomers max



(3)

b)

$2^n \rightarrow 4$ max stereoisomers



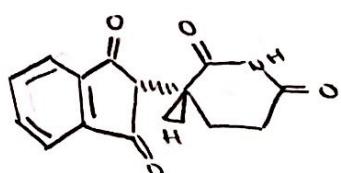
(4)

ID:

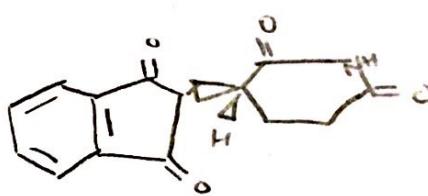
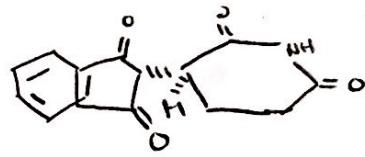
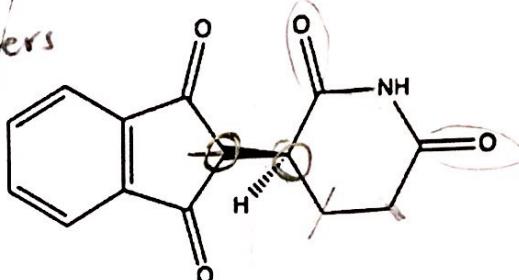
Ex 0

c)

$2^2 \rightarrow \text{max } 4 \text{ stereoisomers}$



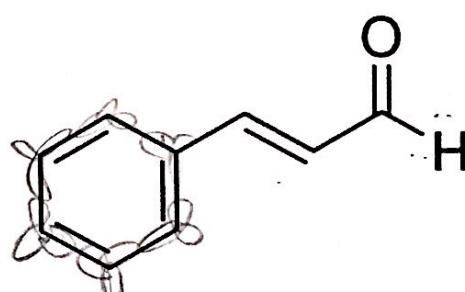
②



d)

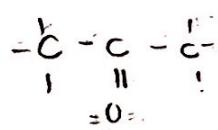
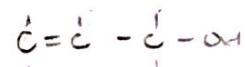
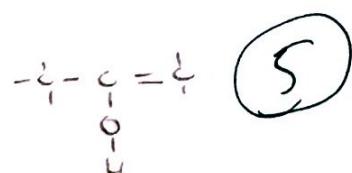
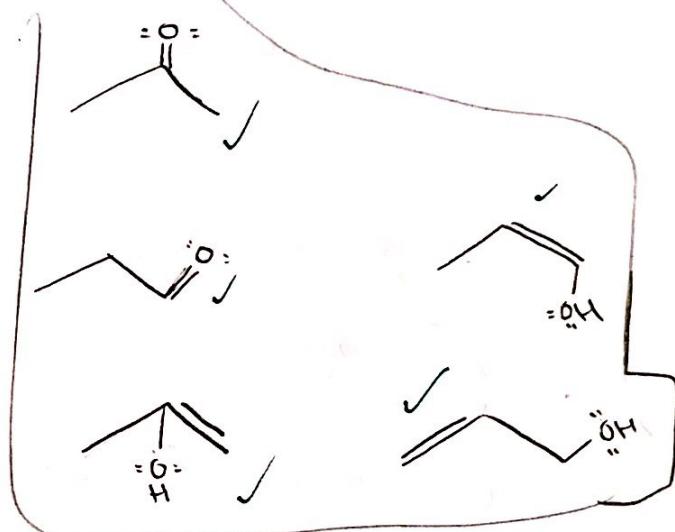
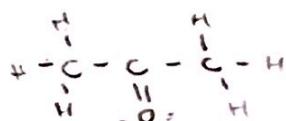
none

②



ID: 50e) Draw 5 isomers with molecular formula C_3H_6O

$$3(4) + 2(1) + 6 = 24 \text{ ve } -\text{es} \quad 12 \text{ bonds (pH)}$$

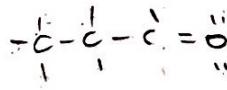


C 3

H 6

O 1

ve 24

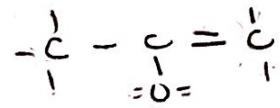


C 3

H 6

O 1

ve 24

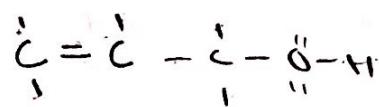
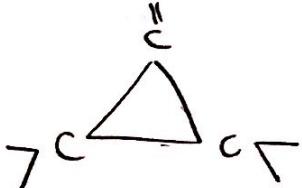


ve 24

H 6

C 3

O 1

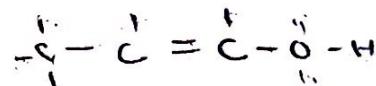


6H

3G

1O

12 3



8H

3C

1O

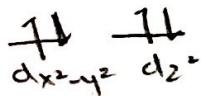
12 3

a) It is known that the transition metal complex $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ has 13 d-orbitals. Predict whether the crystal field energy-level diagram for the complex, labeling the d-orbitals. Predict whether the complex is diamagnetic or paramagnetic. Explain your answers.

Because the complex has isomers, the complex is a tetrahedral.
It has 4 ligands
If it were square planar, isomers would not be possible.

$\text{NH}_3 \rightarrow$ intermediate
 $\text{Cl} \rightarrow$ weak

$$\begin{aligned} \text{NH}_3 &\rightarrow 0 \\ \text{Cl} &\rightarrow -1 \Rightarrow -2 \\ \text{Pt} &= 2+ \\ \text{Pt}^+ &= 5 = \text{d}^7 \\ \text{Pt}^{2+} &= \text{d}^2 \end{aligned}$$



complex is paramagnetic because the complex has 3 unpaired electrons.

③

ID:

CE

b) Draw the crystal field splitting diagrams in octahedral field for Fe^{3+} and Mn^{2+} , show orbital occupancies in both weak and strong octahedral fields, and calculate the number of unpaired electrons

$$\text{Fe} = s^2 d^6$$

$$\text{Fe}^{3+} = d^5$$

weak:

$$\begin{array}{c} \frac{1}{d_{x^2-y^2}} \frac{1}{d_{z^2}} \\ \frac{1}{d_{x^2}} \frac{1}{d_{y^2}} \frac{1}{d_{z^2}} \end{array}$$

5 unpaired e⁻'s

strong:

$$\begin{array}{c} \overline{d_{z^2}} \quad \overline{d_{x^2-y^2}} \\ \frac{1L}{d_{x^2}} \quad \frac{1L}{d_{y^2}} \quad \frac{1}{d_{z^2}} \\ \text{1 unpaired e}^{-} \end{array}$$

$$\text{Mn} = s^2 d^5$$

$$\text{Mn}^{2+} = d^5$$

10

weak:

$$\frac{1}{d_{z^2}} \quad \frac{1}{d_{x^2-y^2}}$$

$$\frac{1}{d_{x^2}} \quad \frac{1}{d_{y^2}} \quad \frac{1}{d_{x^2}}$$

5 unpaired e⁻'s

strong:

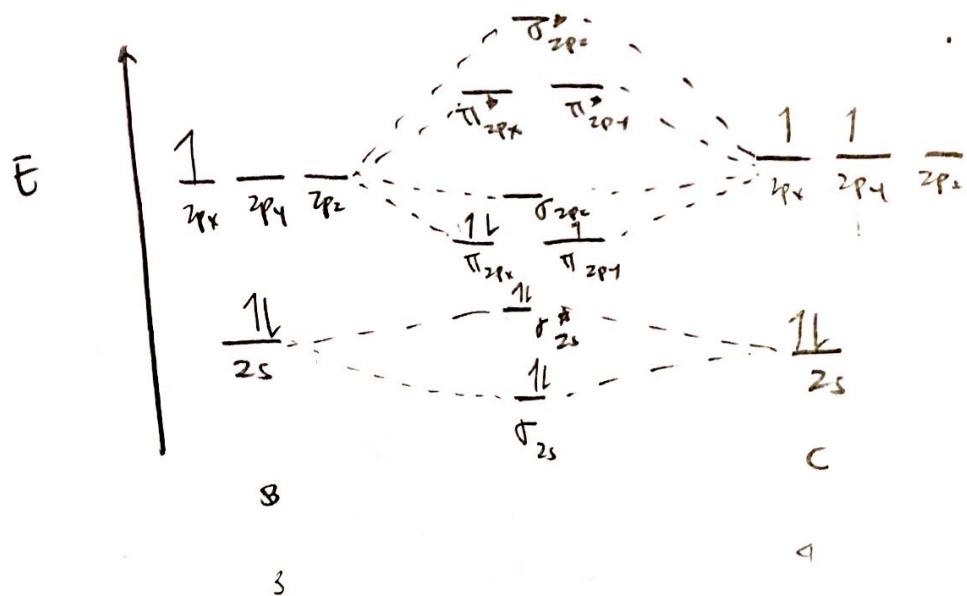
$$\begin{array}{c} \overline{d_{z^2}} \quad \overline{d_{x^2-y^2}} \\ \frac{1L}{d_{x^2}} \quad \frac{1L}{d_{y^2}} \quad \frac{1}{d_{z^2}} \\ \text{1 unpaired e}^{-} \end{array}$$

ID: _____

CECO

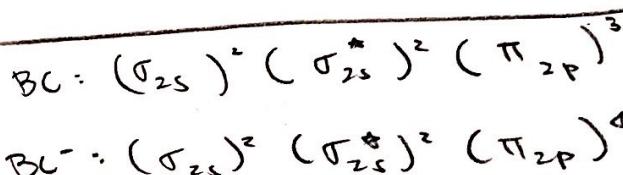
6.

a) Draw a MO diagram for the valence electrons of BC. Label all atomic and molecular orbitals.



6

b) Write the molecular orbital configuration for the valence electrons in BC and in BC⁻.

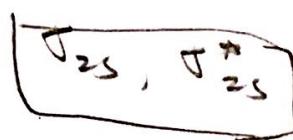


4

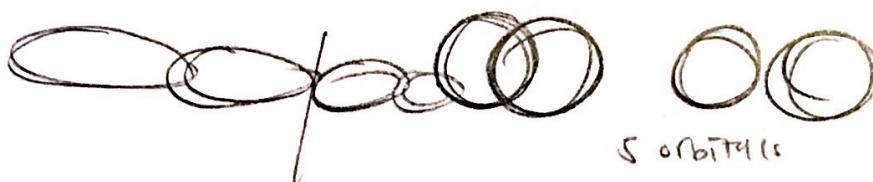
ID:

c) Which of the molecular orbitals in BC do not have a planar node along the internuclear axis?

4



radial node



d) Which of the three has the strongest B-C bond, BC^+ , BC or BC^- ? Justify your answer using bond order.

$$BC^+ = (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^2 \rightarrow BO = \frac{1}{2}(4-2) = 1$$

$$BC = (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^3 \rightarrow BO = \frac{1}{2}(5-2) = 1.5$$

$$BC^- = (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 \rightarrow BO = \frac{1}{2}(6-2) = 2$$

BC^- has the strongest B-C bond because its bond order is the highest of the 3.

5